Overview

- **Visual Displays**
- **Spatial 6DOF Trackers**
- **Hand Devices**
- **Spatial Sound Systems**
- **Graphics Engines**
- **Miscellany**

Input Devices

Position/Orientation (6 DOF)

Trackers

- **Magnetic**
- **Ultrasonic**
- **Optical**
- **Mechanical**
- **Inertial**

Hand

- **Mouse**
- **Spaceball**
- **Dial Box**

Command/Selection

Gestures

- **Fiber Optic**
- **Resistance**
- **Mechanical**
- **Optical**

Speech

- **Isolated**
- **Connected**
- **Continuous**

Biofeedback

- **EMG (Muscle)**
- **EOG (Eye)**
- **EEG (Brain)**

Output Devices

Visual

Head Mounted

- **LCD**
- **Fiber Optic**
- **CRT**

Boom Mounted

- **CRT**

Flat Screen

- **CRT**
- **Projector**

Speech Synthesis

- **Prerecorded**
- **Text to Speech**

Auditory

- **Headphones**
- **External Speakers**

Tactile

- **Air Bladders**
- **Vibrating Transducers**
- **Memory Metals**

Haptic

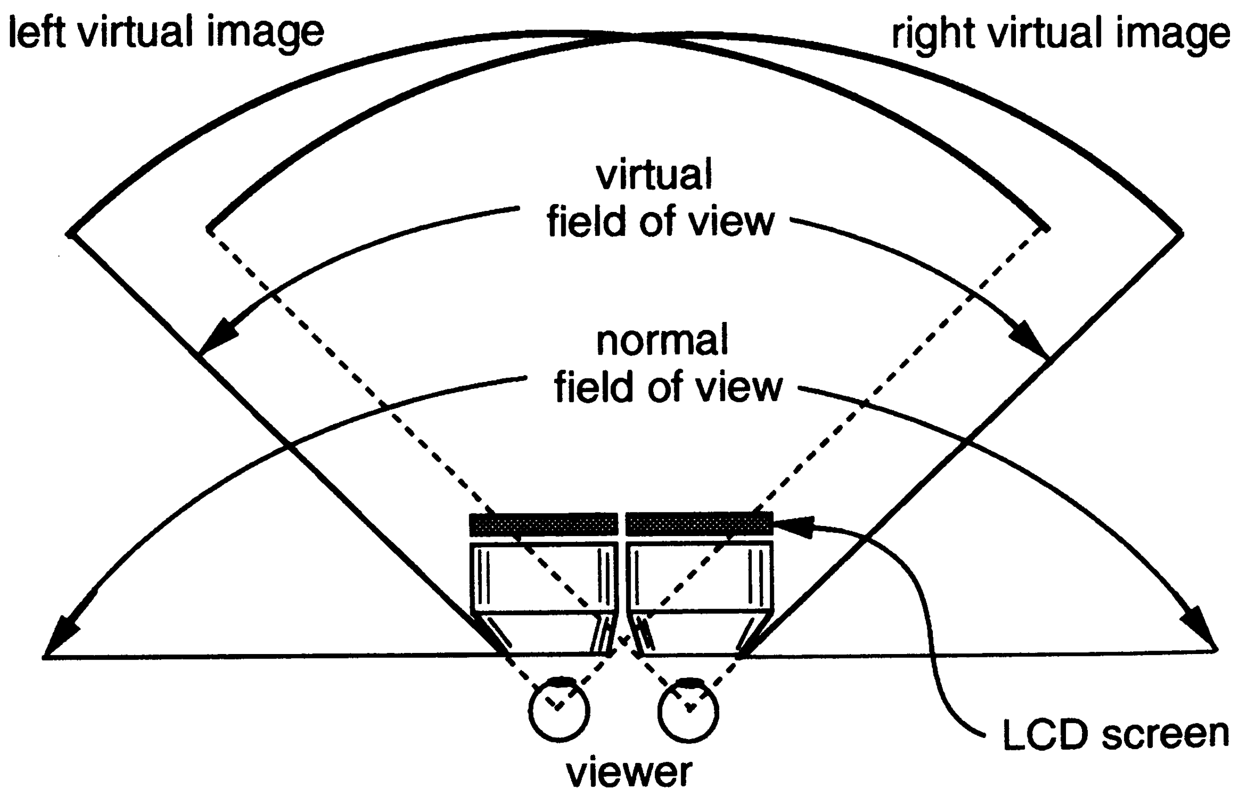
- **Glove**
- **Mechanical Arm**

Visual Displays

The “Perfect” Display

- **light weight**
- **low power**
- **wireless**
- **high resolution**
- **full color**
- **wide (variable) field of view**
- **variable opacity**

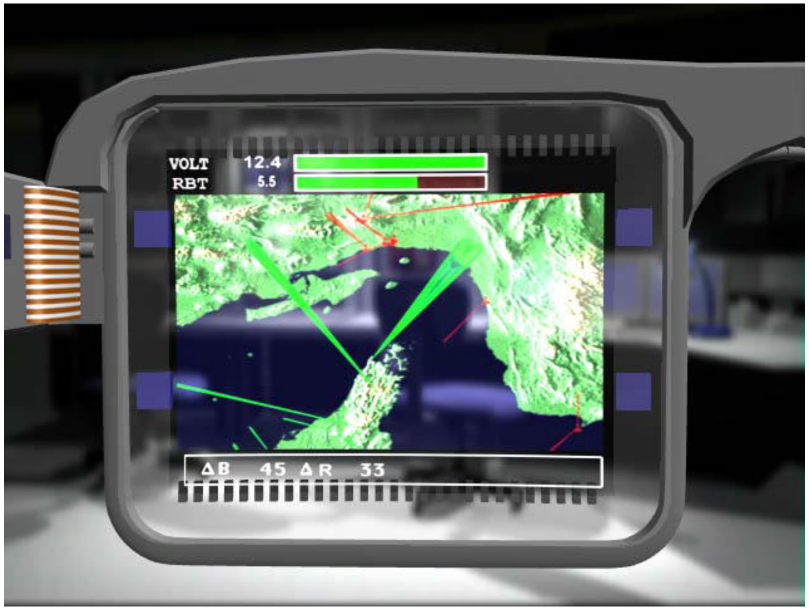
HMD Components



Head-Mounted Displays

- **Characteristics are highly dependent on the technology used in the light-emitting component**
- **Early attempts used LEDs but were monochrome. (Private Eye displays)**
- **Current technology of choice is LCDs which now allow color but are limited in resolution and have high power consumption**
- **We are awaiting the next breakthrough technology....**

The Diffraction Ltd Eye-Worn Display

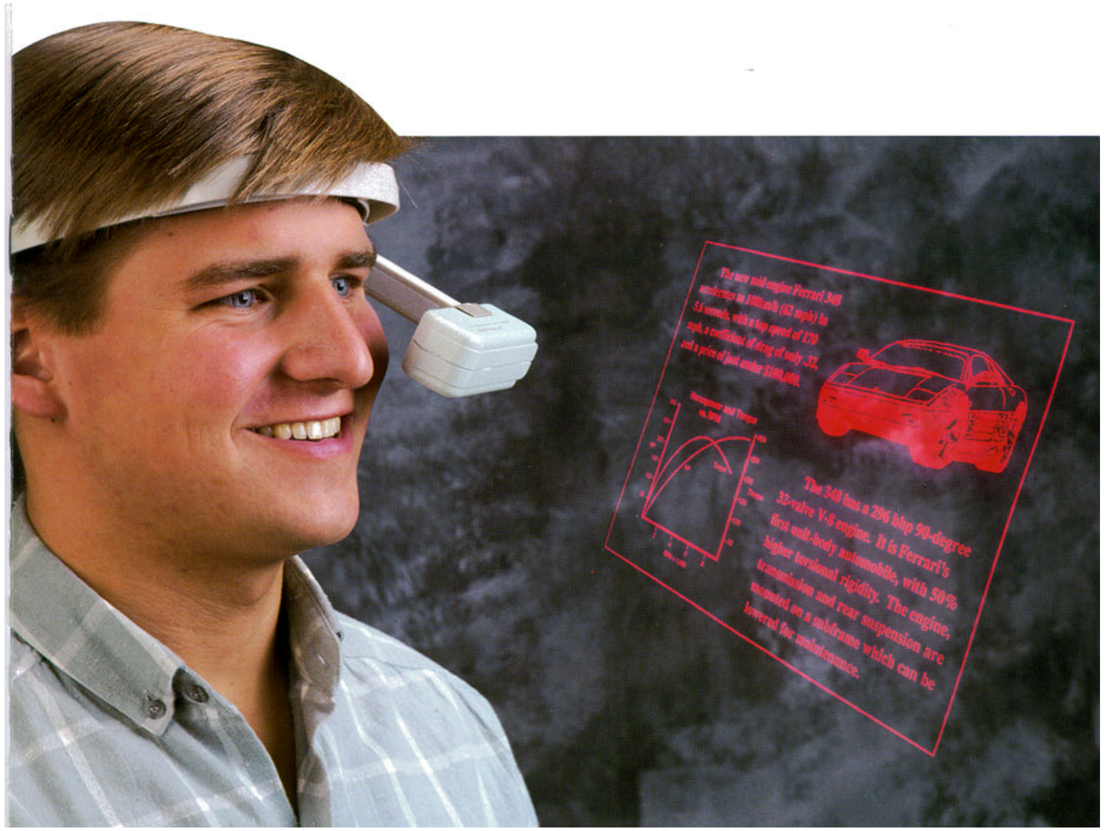


Human Interface Technology Laboratory at the University of Washington

The Retinal Scanner

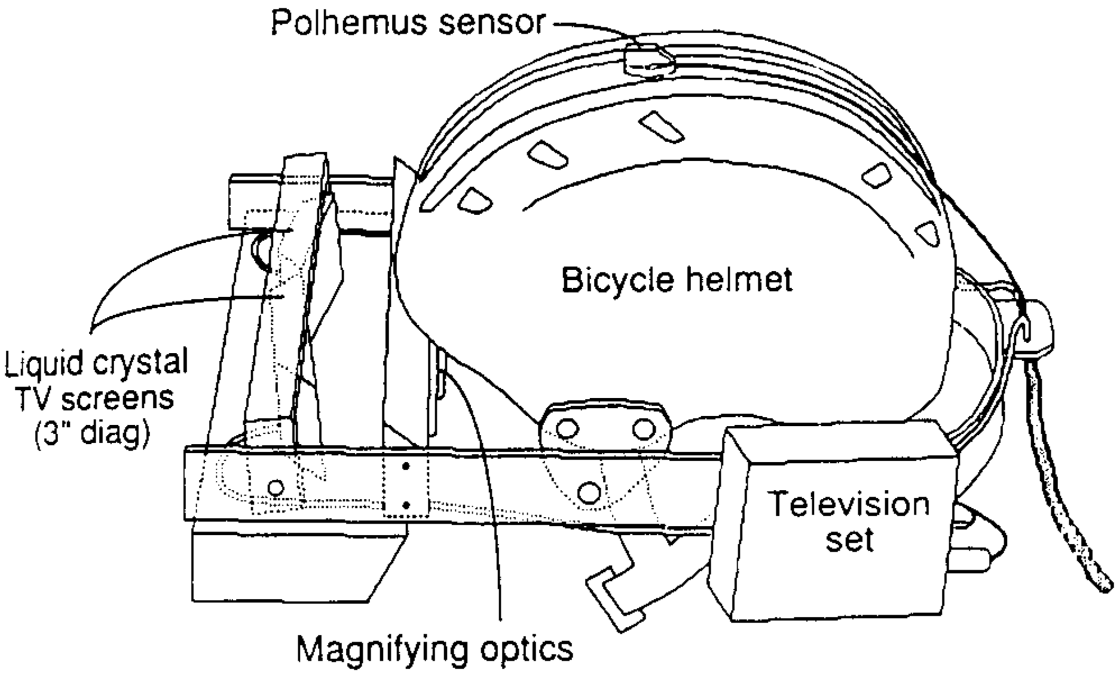
http://www.hitl.washington.edu/projects/vrd/

The Private Eye



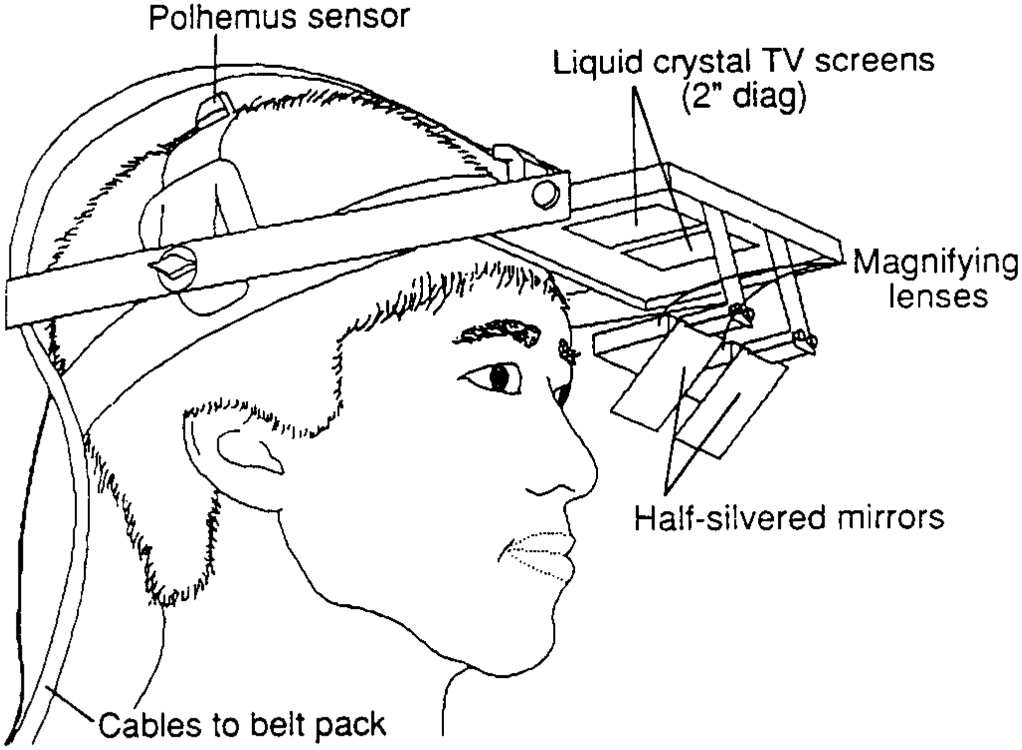
UNC/AFIT HMD

FIGURE 3-29 UNC/AFIT head-mounted display diagram



UNC See-Thru Display

FIGURE 3-30 UNC see-through head-mounted display



The Virtual Research VR4

http://www.virtualresearch.com/

High-End Displays

Kaiser Sim-Eye

CAE Electronics

BOOM
(Binocular Omni-Orientation Monitor)



- **Another approach was to use the best display technology available (which was CRTs at the time) and to mount them on a counterbalanced arm to offset the weight.**
- **This work was pioneered at NASA Ames and now is done exclusively by Fakespace Inc.**

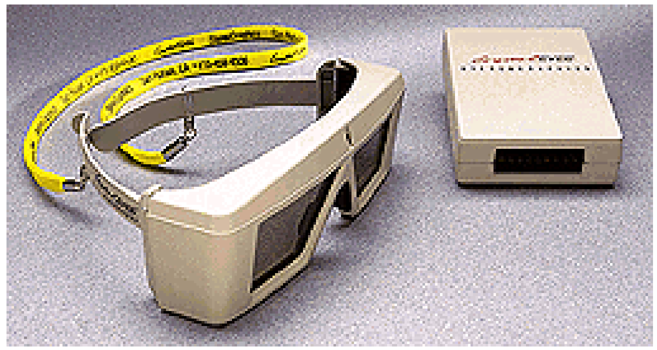
http://www.fakespace.com

PUSH

- **One problem with the BOOM devices is that they are very heavy and bulky.**
- **What many people wanted was a display that could fit on their desk and be used in concert with their workstation display.**
- **The PUSH display stands on three isometric arms that sense intended movement but do not allow large movements to take place.**
- **It has a very small footprint and is cheaper than its larger counterparts.**
- **Also done by Fakespace Inc.**

3D Stereo Graphics

StereoGraphics Crystal Eyes



- **An inexpensive alternative to HMDs or other types of displays is to produce a stereo image on the workstation screen and view it via stereo glasses.**
- **This is a similar approach to 3D movies.**

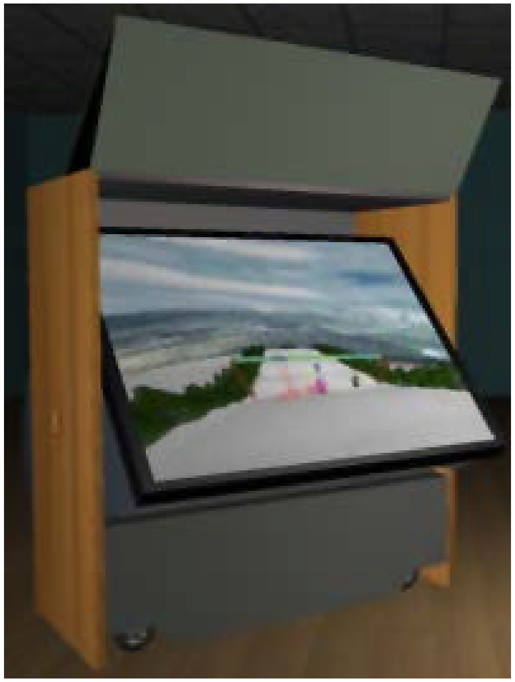
http://www.stereographics.com/

Immersadesk

- **Going a step further, many applications demand a bigger workspace than is offered by a 20” desktop monitor.**
- **Desktop monitors usually stand upright, perpendicular to the table surface.**
- **Many people thought that it would be useful to produce a flat, or near flat, 3D workspace using stereo glasses.**

Immersadesk or Virtual Workbench

http://www.fakespace.com/new_pro.html?



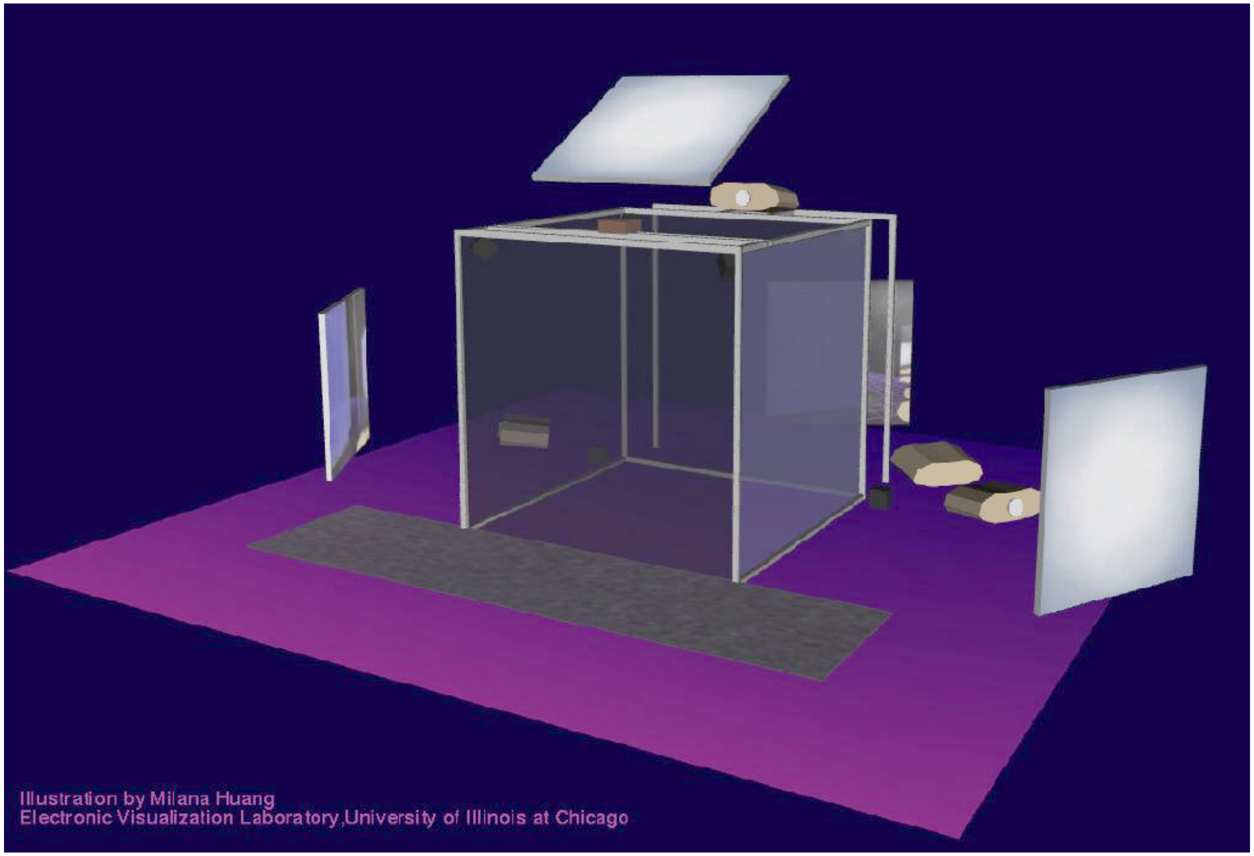
http://www.evl.uic.edu/EVL/VR/systems.html

CAVE

WISE (Walk-In Synthetic Environment)

- **Developed at the University of Illinois at Chicago (C. Cruz-Neira), the CAVE uses several projection screens on the walls and floor in place of an HMD.**
- **Many people can experience the environment simultaneously.**
- **At present, only one can be tracked so others see a distorted image.**

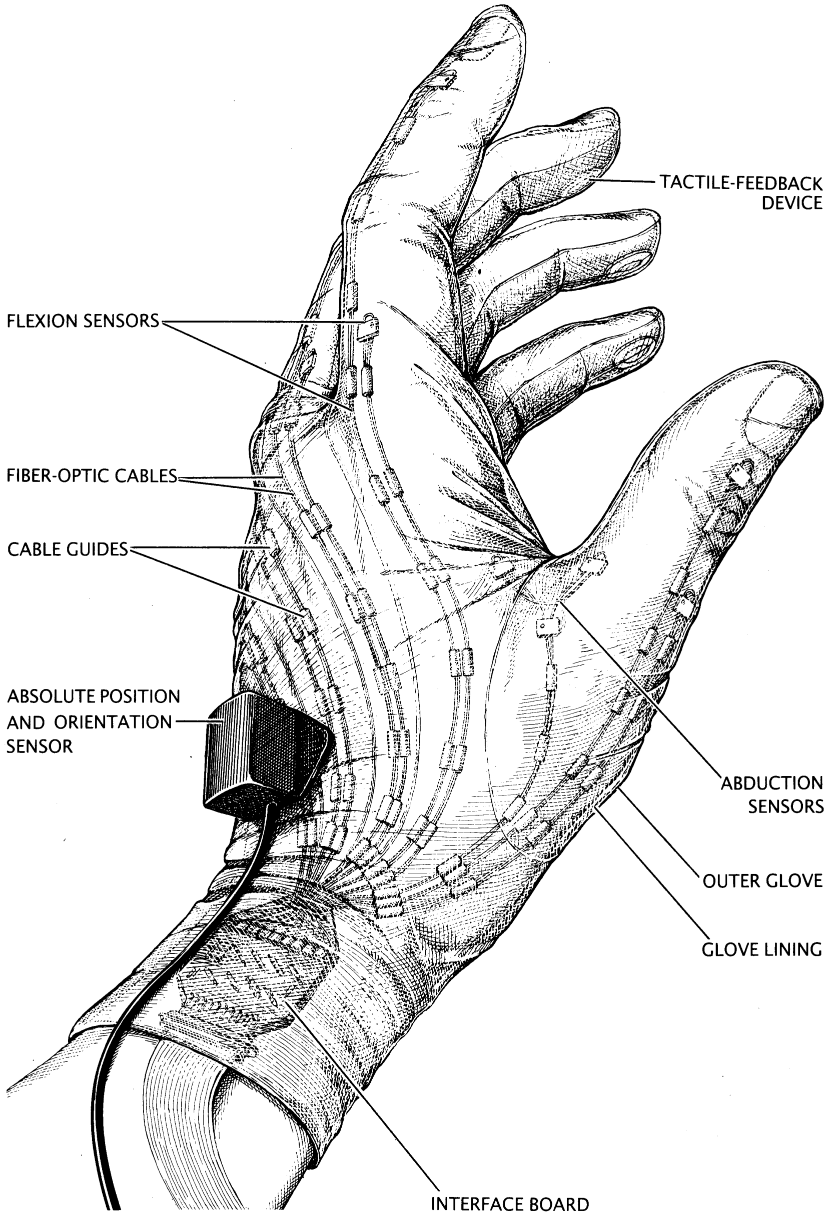
CAVE



http://www.evl.uic.edu/EVL/VR/systems.html#CAVE

Hand Devices

- **Hand worn devices**
  - Dataglove
  - Cyberglove
  - Powerglove
- **Hand held devices**
  - Flying mouse
  - Wand
- **Hand manipulated devices**
  - Spaceball
  - Joystick



The VPL Dataglove

- **The first hand worn device**
- **Fiber optic**
- **Frequent calibration**

Virtual Technologies Cyberglove

- **Stress sensors instead of fiber optics**
- **More degrees of freedom**
- **Less noise and calibration problems**

http://www.virtex.com/~virtex/

video

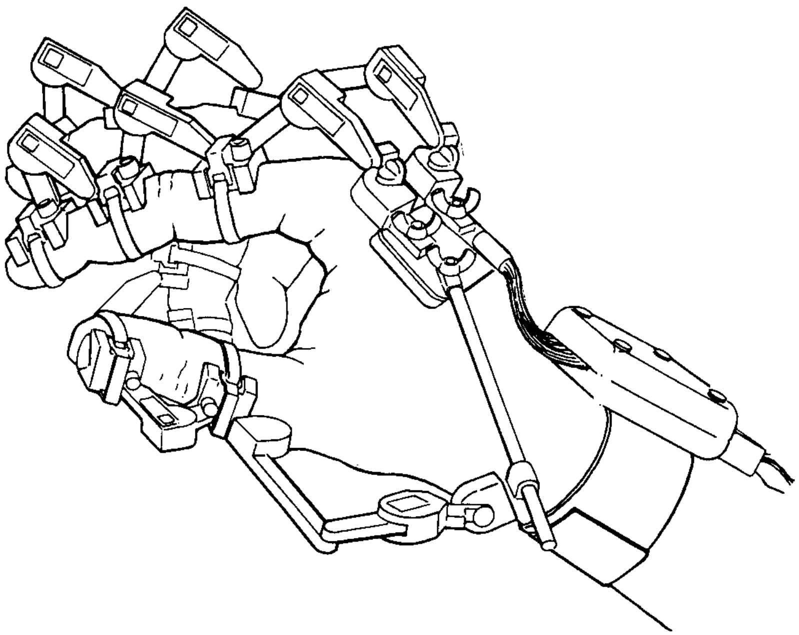
The Powerglove

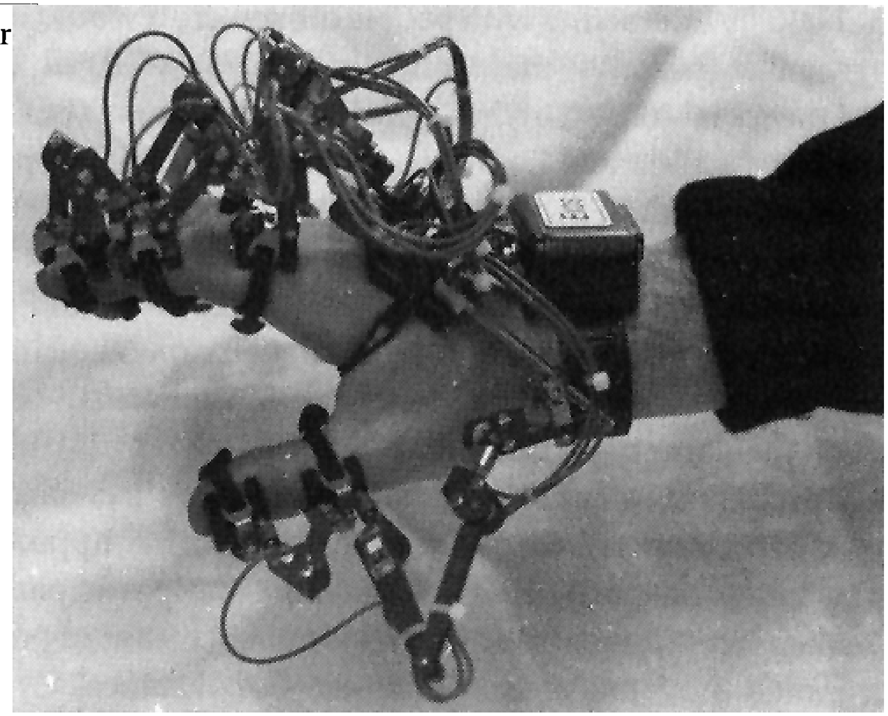
Abrams Gentile Entertainment Inc (AGE)

http://www.cms.dmu.ac.uk/~cph/pg2.html

The Exos Dexterous Hand Master

FIGURE 6-5 Functional diagram of the Dexterous Hand Master

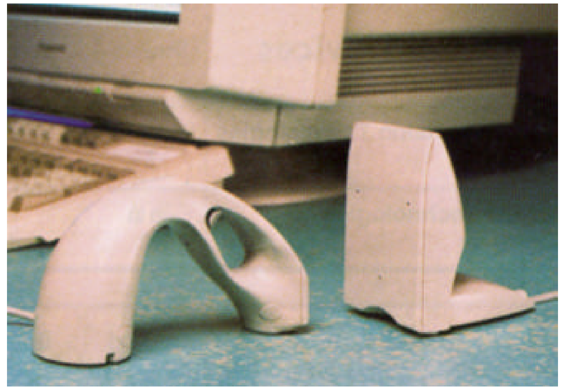


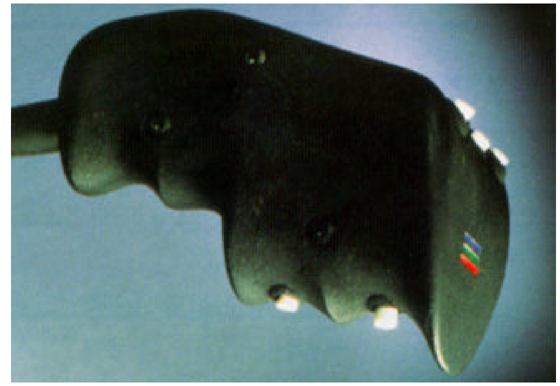


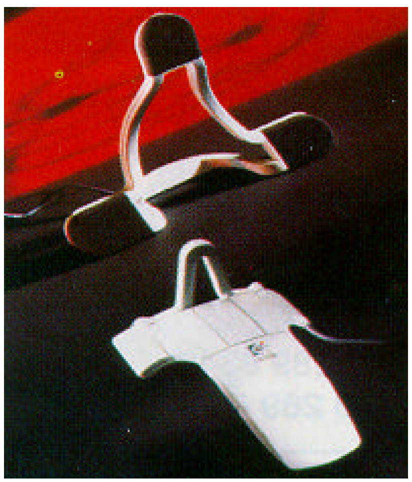
Gestures

- **Gesture ≠ Posture**
- **Fast recognition rates**
- **Lower computation**
- **Accuracy**

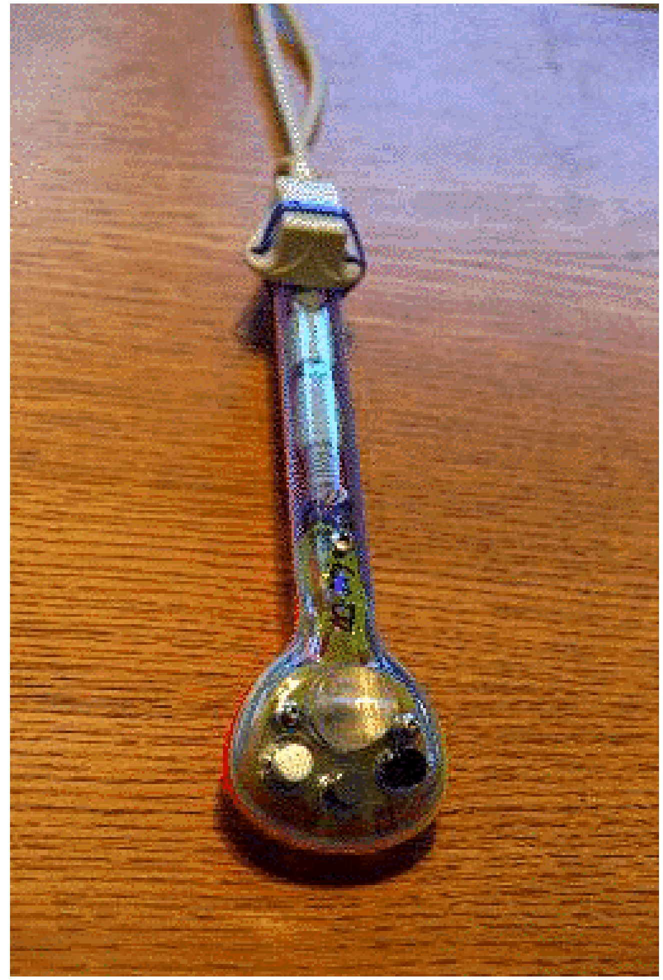
Flying Mouse





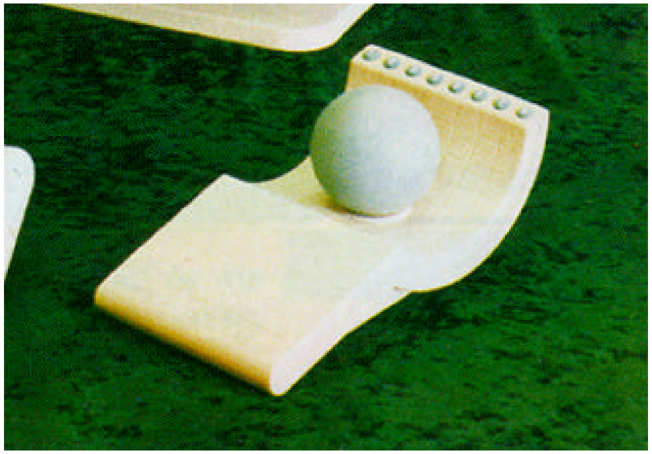


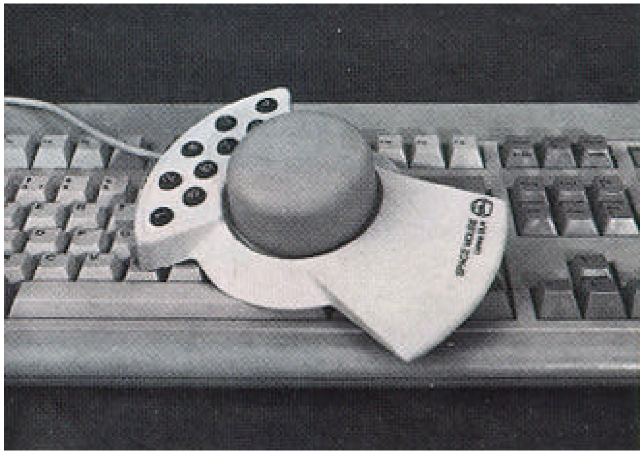
Wand



http://www.evl.uic.edu/EVL/VR/imput.html#wand

Spaceball





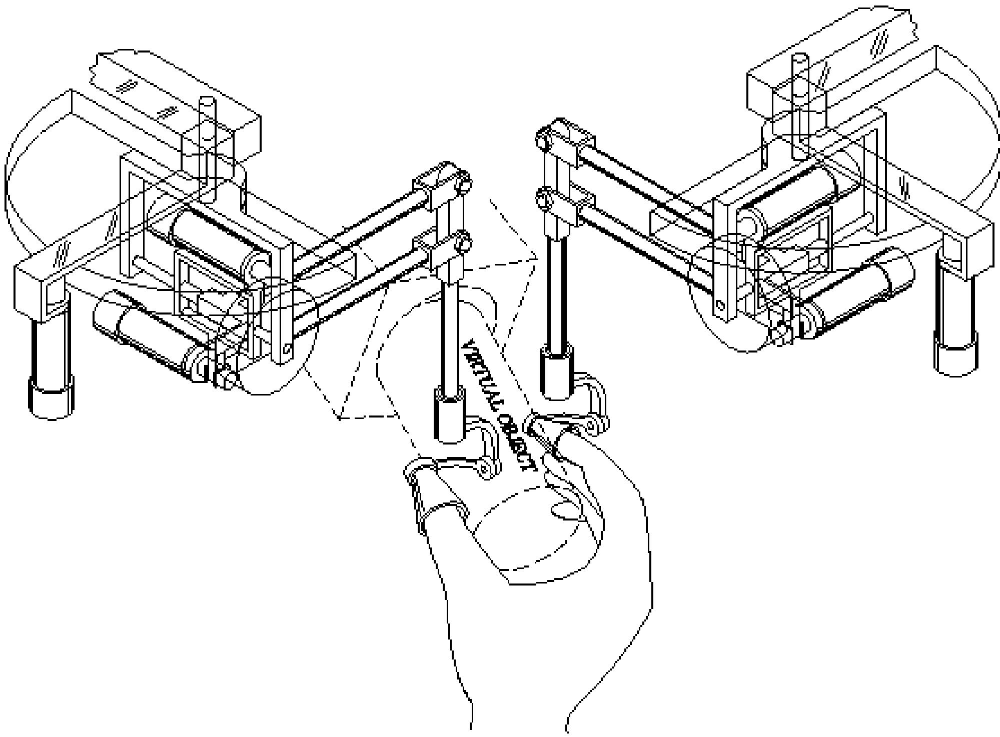
Force Feedback

Haptics

- **UNC Project GROPE**
- **SensAble Technologies, PHANToM**

The PHANToM

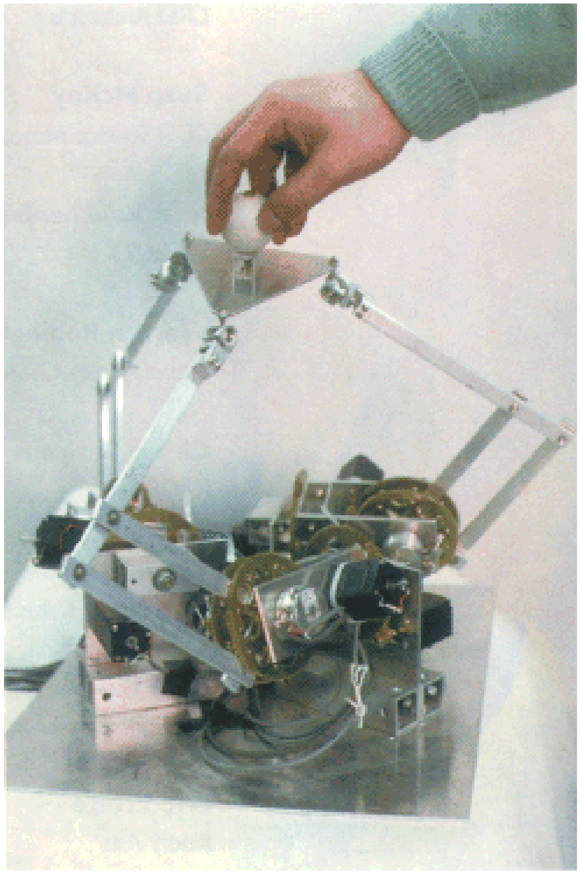
SensAble Technologies, Inc.



http://www.sensable.com/

The Haptic Master

Nissho Electronics Corp.

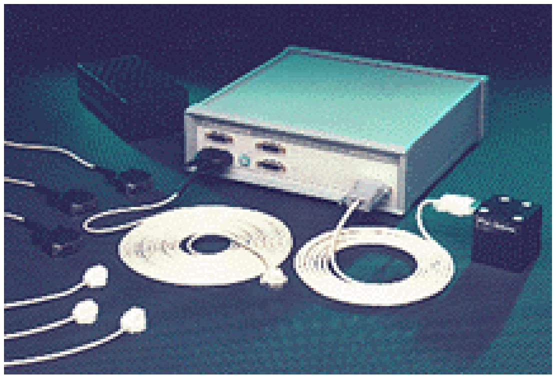


http://intron.kz.tsukuba.ac.jp/HM/txt.html

Spatial Tracking Technologies

- **Magnetic**
- **Ultrasonic**
- **Optic**
- **Mechanical**
- **Inertial**
- **Radio Frequency (RF)**

Magnetic

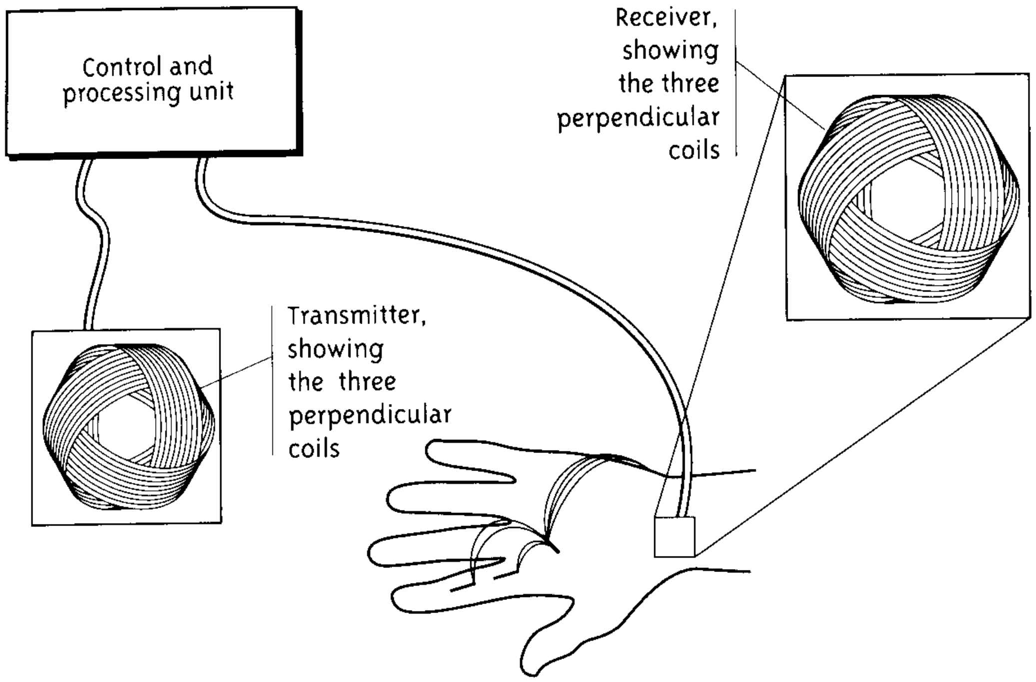


Polhemus Fastrak

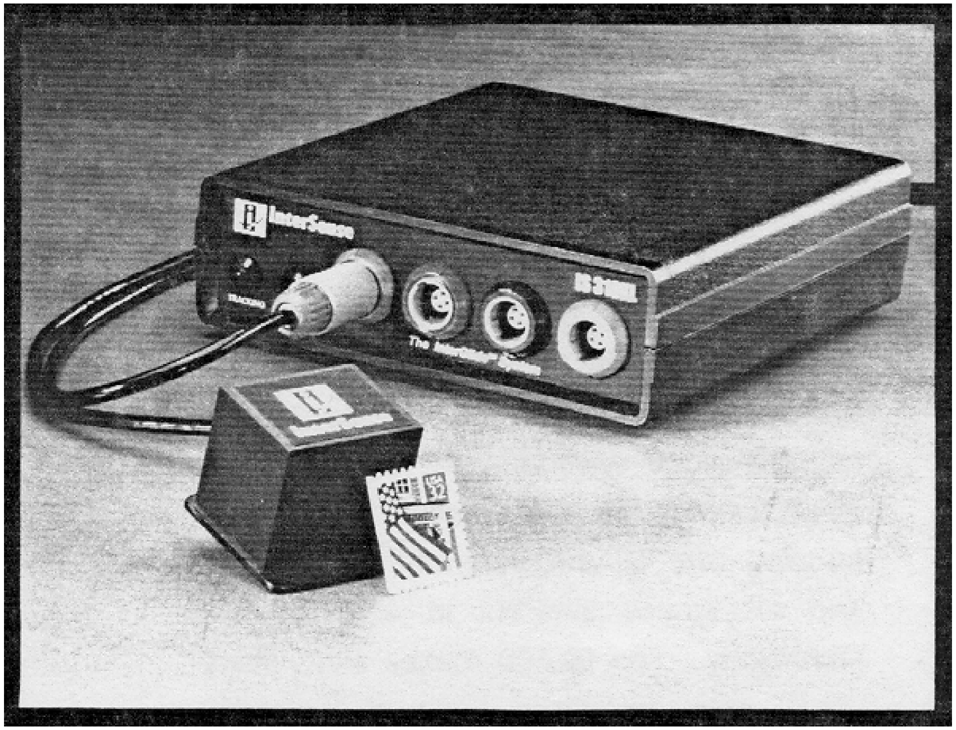
Ascension Flock of Birds

Magnetic Position Sensing

FIGURE 2-3 Magnetic position sensing

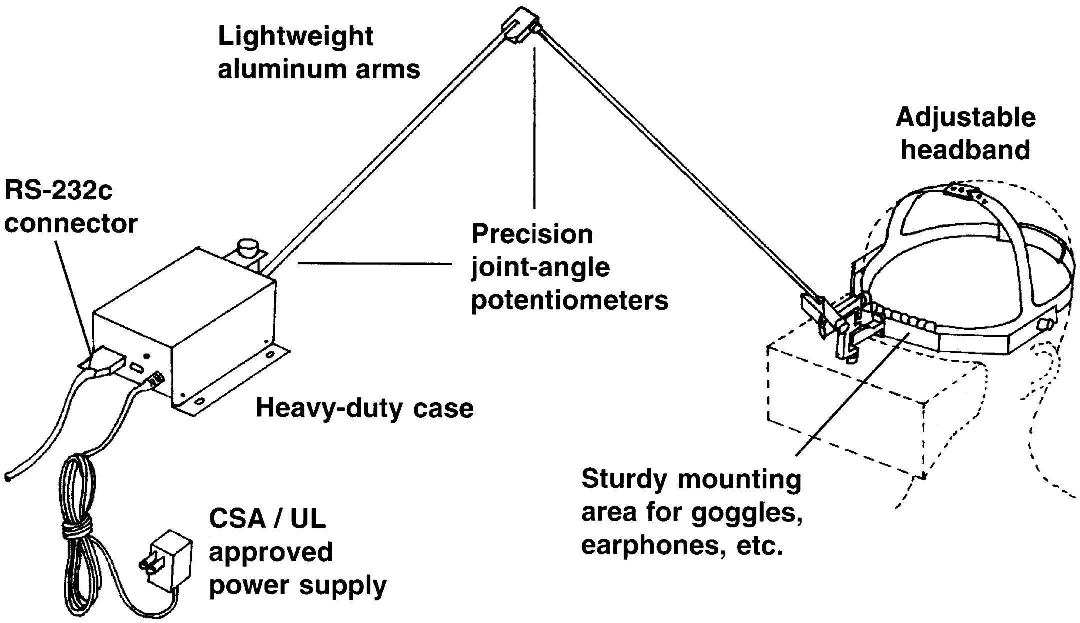


Inertial



InterSense Inc.

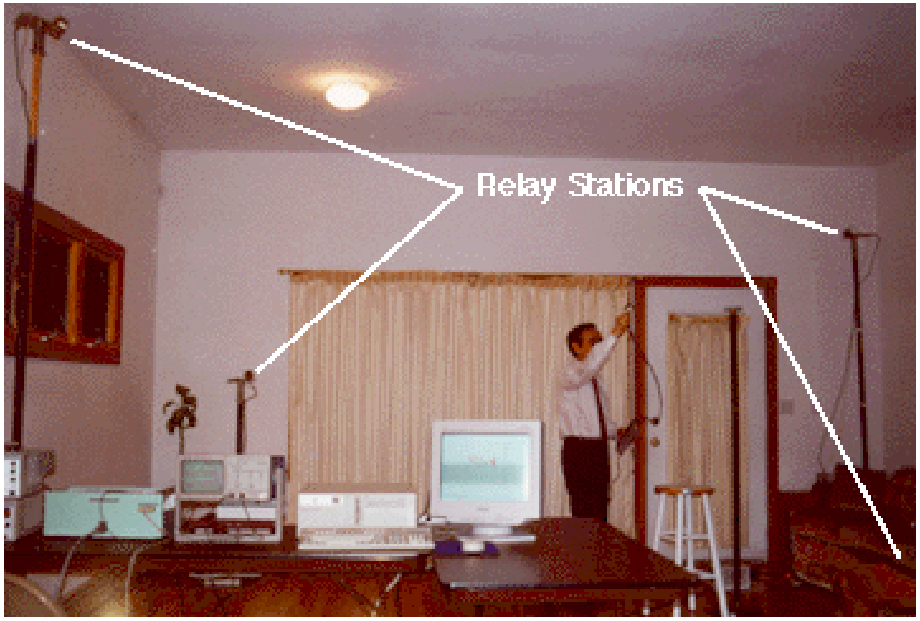
Mechanical

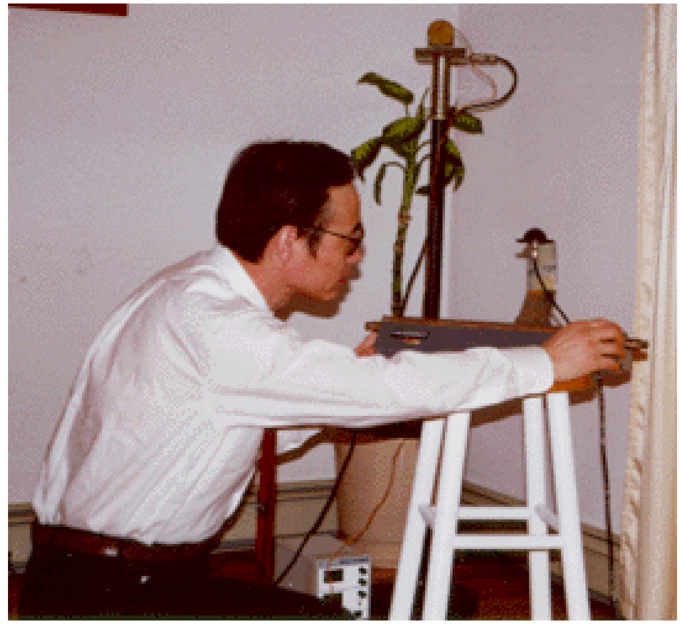


Shooting Star Technology

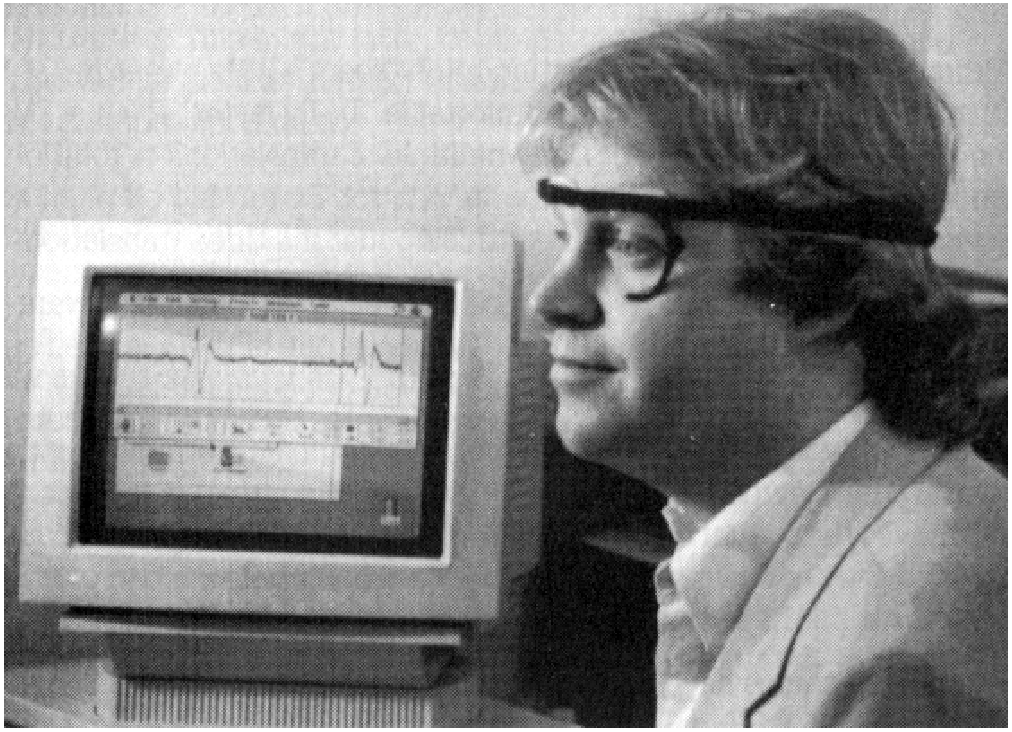
Radio Frequency

Advanced Position Systems, Inc.





Biofeedback



BioMuse

Biofeedback Issues

- **Reliability**
- **Development of interaction techniques**
- **Implicit use**
- **Explicit use**
- **Accurate signal reception**
- **Accurate translation of the signal**
- **Reproducible output**

The Convolvotron

- **The purpose of the Convolvotron was to provide 3D spatial sound**
- **Small microphones were mounted in the ears of a dummy head**
- **Sounds were played at various positions around the head and the amplitudes and phase differences between the sounds arrivals at the microphones were recorded**

The Convolvotron (cont'd)

- **Those parameters were used in the construction of a device, the Convolvotron, that could provide real-time, 3D positioning for sound that was otherwise not positioned. i.e. the sound would be modified for the stereo channels to simulate the phase and amplitude differences that would exist if the sound really was where the Convolvotron placed it.**
- **This work was done by Beth Wenzel of NASA and Scott Foster of Crystal River Engineering...**

UNC's Bicycle

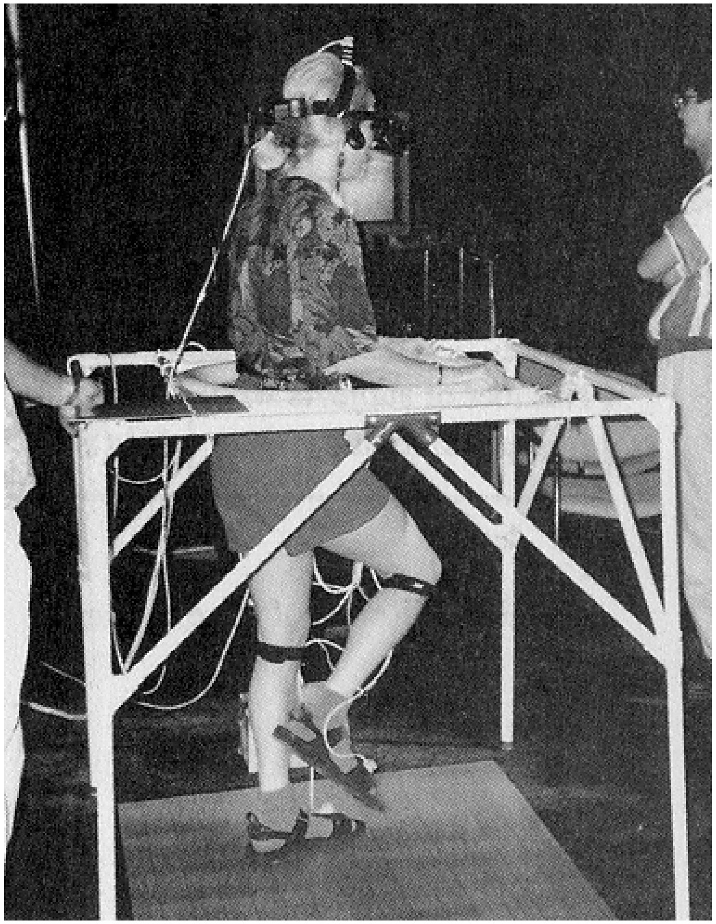
The UniPort

Sarcos

The TreadPort

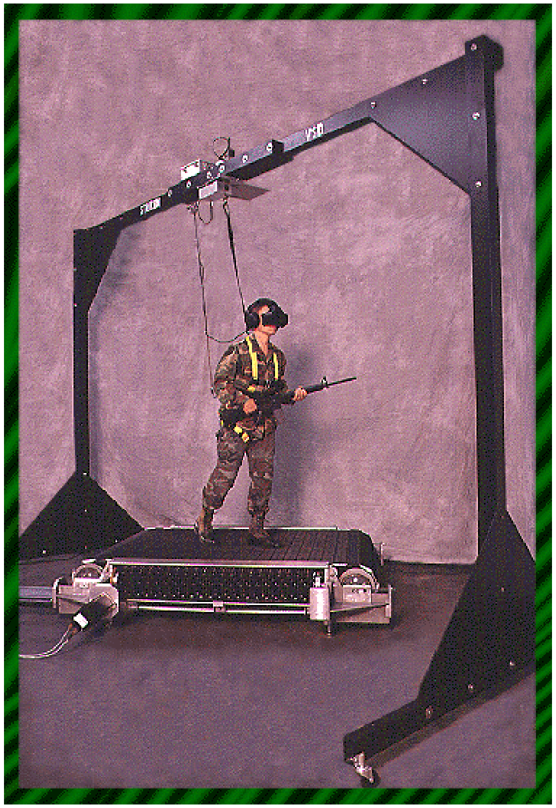
Sarcos

The Virtual Perambulator



University of Tsukuba, Japan

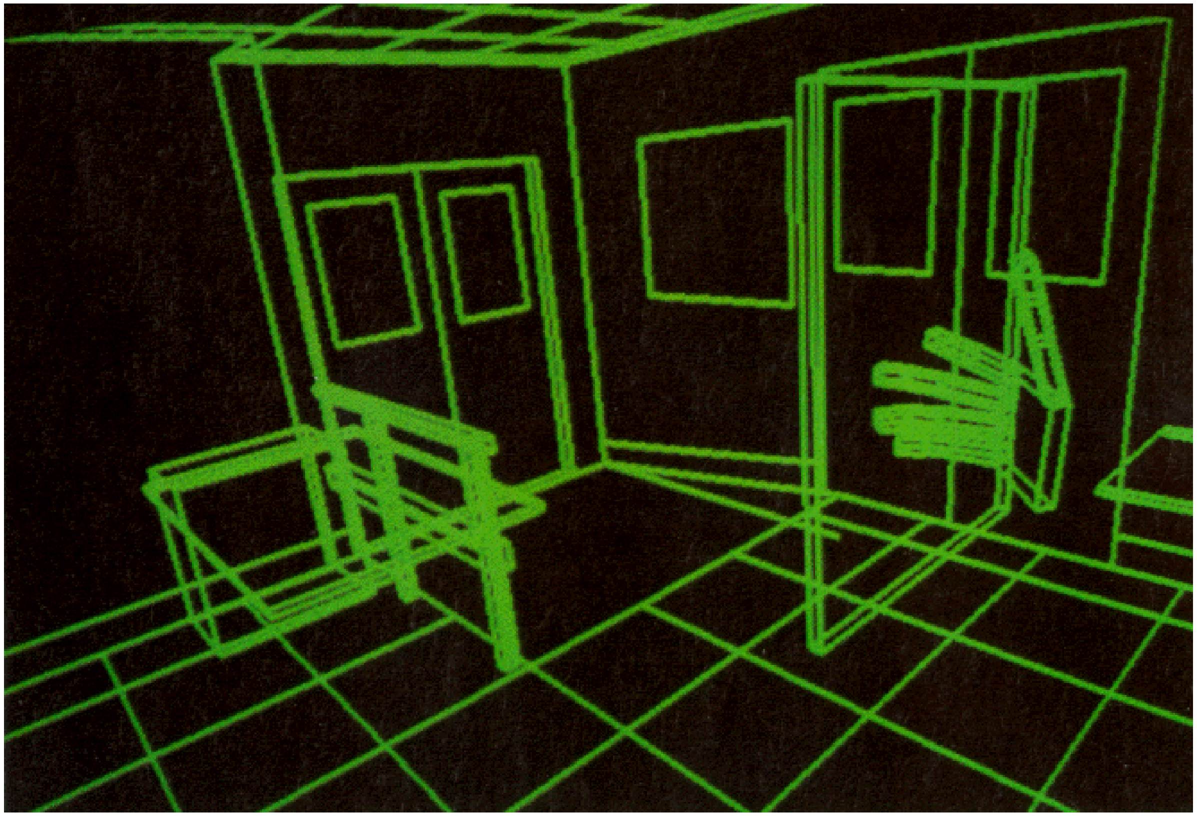
The Omni-Directional Treadmill



Virtual Space Devices, Inc.

video

Early Graphics



Graphics Today

Silicon Graphics, Inc.

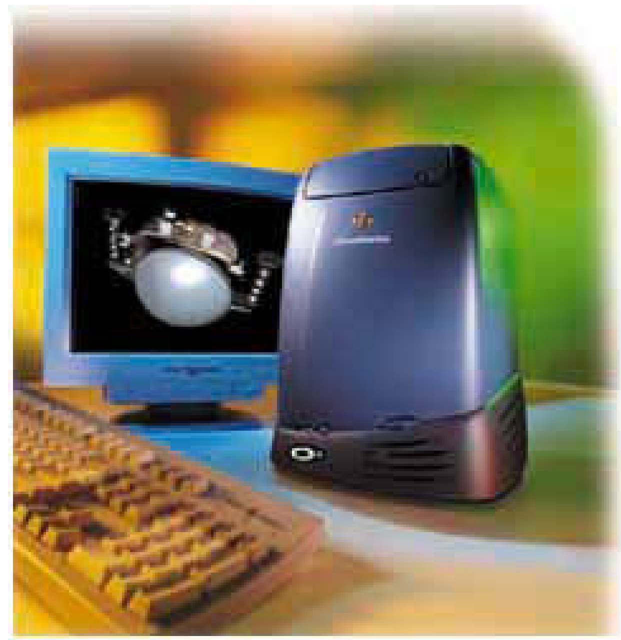
- **8 to 16 4MB cache MIPS R10000 processors**
- **64MB to 8GB RAM**
- **Up to 8 graphics pipelines**
- **Multiple pipe graphics rendering**
- **80 Million Polygons/second**
- **5.3 Gigapixel fill rate**
- **Texture Memory combined for Volume Rendering**
- **Straightforward OpenGL API**

Onyx2 RealityMonster
$$$$

Graphics Today

Silicon Graphics, Inc.

• **Pixels/Sec Goraud Filled**	**33M**
• **Pixels/Sec Textured**	**33M**
• **Triangles/Sec Flat**	**770K**
• **Triangles/Sec Goraud**	**475K**
• **Triangles/Sec Textured**	**193K**



02

$

Graphics Today

Intergraph, Inc.

INTERGRAPH
COMPUTER SYSTEMS

TDZ 3D GRAPHICS WORKSTATIONS

- Windows NT
- 200 MHz Pentium Pro processors
- Up to 1GB RAM
- 2.5 million pixels
- Double-buffered
- True color
- Textured, 64MB
- >1.2 million polygons/sec

video